Environment Canada Environnement Canada

INLAND WATERS DIRECTORATE STRATEGY FOR ADDRESSING ATMOSPHERIC ISSUES

Inland Waters Directorate
Environment Canada

IWD Network on Atmospheric Issues

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TABLE OF CONTENTS

PART 1 - STRATEGIC PLAN

Background 1-1

Purpose 1-1

Guiding Principles 1-1

Problems and Priorities 1-1

Analytical Framework 1-2
- Science 1-2
- Impacts 1-2
- Responses 1-2

Clients and Partnerships 1-3
- Departmental 1-3
- Federal and National 1-3
- International 1-3

Goals 1-3
- Global Warming 1-4
- Acidification 1-4
- Airborne Toxics 1-5
- Stratospheric Ozone Depletion 1-5
- Tropospheric Ozone Production 1-5

Implementation and Evaluation 1-5

PART 2 - ACTION PLAN

Global Warming 2-1

Acidification 2-6

Airborne Toxics 2-9

Stratospheric Ozone Depletion 2-11

Tropospheric Ozone Production 2-12

TABLE OF CONTENTS (cont'd)

Appendix A - Background Information

Introduction	A-1
Atmospheric Issues	A-1
Collective Rationale	A-2
Response Strategy	A-2
Considerations	A-4
International Context	A-4
National Context	A-6
IWD Activities	A-8
Current Efforts	A-8
Near-Future Commitments	A-9
Longer-Term Needs	A-12

LIST OF FIGURES

1.	Tracking Atmospheric Issues -International	A-5
2.	Tracking Atmospheric Issues - National	A-7
3.	National Management Structure for Atmospheric Issues	A-10

LIST OF TABLES

1.	Predominant Airborne Substances and Related Atmospheric Issues	A-3

PART 1

STRATEGIC PLAN

Inland Waters Directorate
Strategy for Addressing Atmospheric Issues

(May 1991)

Background

Appendix A provides the context upon which the **IWD Strategy for Addressing Atmospheric Issues** is based. Given this context, IWD is obliged to address atmospheric issues, the related current and potential problems, and the impacts of these problems within the IWD sphere of activity.

Purpose

Achievment within IWD of a common understanding of and a coordinated, effective and efficient response to atmospheric issues in support of the sustainable use of water.

Guiding Principles

- Resolution of water problems and related socio-economic concerns through anticipative and preventative planning approaches and flexible management techniques that make environmental and economic sense under current circumstances while respecting the uncertainties of the future.

- Integration of work through shared sites, equipment and labour; synthesis of data from a variety of relevant sources; interdisciplinary teams from a variety of organizational units inside and outside IWD and C&P; and linking policy, strategy, science and knowledge generation aspects.

- Targeted research in support of ecosystem-wide integrated understanding, the regulatory regime, State of the Environment reporting, education and awareness programming, use of economic instruments, and Canadian contributions to pertinent international actions.

- Technological advancement, by using modern tools and techniques for research and monitoring, in parallel with human resource development to maintain and augment staff expertise.

Problems and Priorities

For IWD purposes, **atmospheric issues** are phenomena caused by the changing composition and behaviour of the atmosphere, which result in impacts at micro-to-macro scales on freshwater ecosystems and associated human and natural systems. In order of relative priority, IWD should address the following atmospheric issues:

- global warming
- acidification
- airborne toxics
- stratospheric ozone depletion
- tropospheric ozone production.

This list should be updated as required.

Analytical Framework

The analytical framework of the Strategy is the same as that used for national (i.e. LRTAP) and international (i.e. IPCC) actions on atmospheric issues. In addition to this compatability, the framework represents an orderly model for the development of sound knowledge and information and its application to the resolution of atmospheric issues. Finally, the framework provides a basis for a simple and rational program implementation and management structure.

Science Responding to the possible impacts of atmospheric issues on water resources and water users begins with good science. Science and science-related activities at IWD research institutes and regional locations should improve the basic understanding and modelling of the hydrological cycle in terms of atmosphere-water relationships affecting both the quantity and quality aspects. IWD efforts should also address the role of the hydrosphere as a source, pathway and sink relative to atmospheric issues. IWD needs to develop new knowledge on the cumulative impact of atmospheric issues and other environmental stresses on aquatic ecosystems.

Impacts Reliable information and realistic models are needed to understand better past and present conditions and to identify confidently trends relative to the existing and potential impacts of atmospheric issues on regional and national water resources. Water quantity, quality and use monitoring and modelling activities by IWD should provide readily accessible and usable data for atmosphere-related change detection and scenarios for impact assessment and awareness relative to water resources and socio-economic systems. An important application of impact scenarios for atmospheric issues should be through the rejuvenated Environmental Assessment Review Process, for the assessment of both the effects of climate change and the implications of response options.

Responses The goal of IWD activities related to atmospheric issues is to provide knowledge that should enable development of appropriate responses to effects on hydrology, water resources and society. Studies of vulnerability and resilience of water-dependent social, economic and institutional systems should include analysis of existing policies and programs. The most sensitive regions and watersheds, in terms of both environmental and societal well-being, should be identified and given priority for urgent action. Adaptation and limitation options should be assessed through modelling and policy analysis.

Implementation of the analytical framework begins with identification and consolidation of the individuals and activities according to the science, impact and response aspects of atmospheric issues. Achievement of an efficient and effective effort to address atmospheric issues requires good communication and understanding among those involved in the three analytical groups.

Clients and Partnerships

Departmental The corporate levels of Conservation and Protection and Environment Canada shall continue to be among the primary targets for results of the collective effort within IWD relative to atmospheric issues. Partnerships with the protection and wildlife areas of C&P and the other services and specialty groups within DOE should be maintained and improved through the existing committee system and less formal contact and communication.

Federal and National Similar lines of communication and coordination that exist between IWD and other government departments, particularly Agriculture, Energy, Mines and Resources, Fisheries and Oceans, Forestry and Health and Welfare, should be continued and enhanced as required. IWD efforts to serve client needs of and to form partnerships with provincial (particularly regarding ground water issues) and territorial governments, educational institutions, industry, non-governmental organizations and the general public of Canada should be continued and enhanced.

International IWD input to more distant interdepartmental/ federal and national level (Canadian Council of Ministers of the Environment) clients should be a priority since it is often destined, with mediation by External Affairs, as contributions to international actions. Alternatively, IWD should maintain and if necessary establish direct linkages with both governmental (Economic Commission of Europe, World Meteorological Organization) and non-governmental (International Water Resources Association, International Association of Hydrological Sciences) that have been identified as priority clients and partners.

Goals

The following issue-specific goals are based on IWD intentions as articulated in the Green Plan and long-term operational plans. Needs and priorities as identified by consensus among Canadian and, to a lesser extent, international experts are also considered as they pertain to IWD concerns and areas of interest. Even though the issue of **tropospheric ozone production** is not being actively addressed within IWD, its potential effects on aquatic ecosystems indicate that it should be included in this edition of the IWD Strategy for Addressing Atmospheric Issues.

1. **Global Warming**

   1.1 To identify and assess the potential impacts of climate change, positive and negative, on the hydrological cycle, aquatic ecosystems, regional water resources, and related human activities.

   1.2 To identify and assess the influence of terrestrial water systems on global warming, with an emphasis on greenhouse gas sources, pathways and sinks.

   1.3 To develop and implement tools and techniques for monitoring and detecting the effects of climate change on freshwater ecosystems and the role of the hydrosphere relative to global warming.

   1.4 To develop and implement tools and techniques for monitoring and detecting the effects of climate change on water-related human activities and on an integrated, regional basis.

   1.5 To identify appropriate options for mitigating the most serious negative effects and benefiting from the positive effects of climate change on the freshwater environment and society.

2. **Acidification**

   2.1 To continue to detect and monitor acidification by SO_2 and NO_2, its effects on aquatic ecosystems, and the impact of limitation and remedial efforts, with increasing emphasis on nitrogen deposition.

   2.2 To continue to identify and assess the impact of acidification by SO_2 and NO_2 on water-related human activities, with increasing emphasis on nitrogen deposition.

   2.3 To determine loading criteria for limiting acidification impacts in aquatic ecosystems by SO_2 and NO_2 on a regional basis, with increasing emphasis on nitrogen deposition.

   2.4 To provide sound scientific data in readily accessible and usable form for periodic national assessments of aquatic ecosystem and socio-economic responses to emission controls and for national, Canada/U.S. and other multinational negotiations on SO_2 and NO_2 emissions, with increasing emphasis on nitrogen deposition.

3. Airborne Toxics

3.1 To determine input/output balances and internal cycling behaviour of priority airborne toxics within aquatic ecosystems.

3.2 To identify and monitor effects of priority airborne toxics on aquatic ecosystems and freshwater biota.

3.3 To determine loading criteria on a regional basis so that aquatic ecosystems are not impaired in their evolution and functioning by airborne toxics.

4. Stratospheric Ozone Depletion

4.1 To determine the effects of ambient levels of UV radiation on aquatic ecosystems.

4.2 To conduct experimental research to confirm preliminary evidence of effects of increased UV radiations on aquatic flora and fauna in lakes and rivers.

5. Tropospheric Ozone Production

5.1 To determine the direct and indirect effects on aquatic ecosystems resulting from the absorption of ground-level ozone.

5.2 To determine the direct and indirect effects on aquatic ecosystems resulting from the attenuation of UV and visible radiations.

Implementation and Evaluation

The **IWD Strategy for Addressing Atmospheric Issues** should be implemented through the regular operational planning processes, primarily annual work plans and long-term operational plans. Implementation should take the form of a specific program element based on a consolidation of new resources from the Green Plan with reallocated existing resources. Aspects of atmospheric issues with insufficient current funding and human resources include:

- improved scientific understanding of atmosphere-based hydrological processes (i.e. evaporation, precipitation);
- improved scientific understanding of cumulative, aquatic ecosystem impacts related to atmospheric issues;
- enhanced socio-economic studies and policy analysis of water-related impacts of atmospheric issues; and
- expanded integrated monitoring nationally, but especially in the North and relative to priority toxic substances from the atmosphere.

The target for commencing implementation is fiscal year 1991-1992. **Part 2** provides an initial **Action Plan**, which relates specific activities/products to the goals stated above, as a basis for implementing the Strategy. The Action Plan is not a work plan; rather, it is intended to be used as a catalogue and guide to facilitate work planning in response to the Strategy. It consists primarily of excerpts from the 1990-91 IWD Work Plan Synopses, with additional information on existing and proposed activities, as provided by the IWD Network on Atmospheric Issues. Even though the Network verified the information, some inaccuracies may remain.

The Strategy and its program results should be evaluated after five years in terms of effectiveness and efficiency. The **IWD Network on Atmospheric Issues** should meet annually to review project progress, discuss work plans and exchange information. Future editions of the Strategy should take into account the following factors: new knowledge and information on the effects of atmospheric issues on the hydrological cycle, aquatic ecosystems and water resources; emission reduction benefits that may result from federal, provincial and international control programs; and new priorities and future needs as defined at the directorate, service, departmental and federal levels.

PART 2

ACTION PLAN

Inland Waters Directorate
Strategy for Addressing Atmospheric Issues

(May 1991)

(Legend on page 2-13)

Issue 1. GLOBAL WARMING

Goal 1.1 To identify and assess the potential impacts of climate change, positive and negative, on the hydrological cycle, aquatic ecosystems, regional water resources, and related human activities.

Products 1.1

(1) assessment of impacts of global climate change and sea-level rises on river profile and economic viability of dykes
Regional **Pacific & Yukon** **1991/92 - 1993/94**

(2) improvement of understanding of hydrological regime of MacKenzie Delta lakes and interactions between hydrology and delta ecosystem in order to improve predictions of effect of climate warming, including contribution to AES-led MacKenzie Basin Impact Study
Regional **NHRI** **1991/92 - 1996/97**

(3) participation in study "Investigation of the Effects of Climatic Variability/Change on Wetlands" - Phase I, including contribution to BOREAS experiment, to establish effect of climate warming on permafrost-hydrologic divides controlling storage of water within northern wetlands and model decay of permafrost divides and subsequent effect on hyrological system
National **NHRI** **1991/92 - ? (Phase 2 uncertain)**

(4) assessment of macro-level climate-hydrology relationships, particularly in western (mountain, prairie) and northern regions, using glacial mass balance monitoring and analysis; including contributions to MacKenzie Basin Impact Study and GEWEX
Regional **NHRI** **1991/92 - 1996/97**

Issue 1. **GLOBAL WARMING (Products--Goal 1.1)** (cont'd)

(5) completion and distribution of IWD Fact Sheet on "Climate Change and Water Resources"
National **WP&MB-HQ** **1991/92**

(6) overall assessment of impact of climatic variability and change on water resources in New Brunswick
Regional **Atlantic** **? (new resources required)**

Goal 1.2 To identify and assess the influence of terrestrial water systems on global warming, with an emphasis on greenhouse gas sources, pathways and sinks.

Products 1.2

(1) assessment of potential contribution of data on dissolved organic carbon in regional, ocean-bound freshwater systems to understanding carbon cycle and climate system
National **Atlantic (NHRI)** **1991/92 - 1996/97**

(2) data report on progress of Northern Wetlands Project on role of Hudson Bay wetlands relative to global atmospheric concentration of methane (greenhouse gas)
National **NWRI (NHRI)** **1991/92 - 1996/97**

(3) assessment of exchange of greenhouse gases at the air-water boundary
National **NWRI** **1991/92 - 1996/97**

Goal 1.3 To develop and implement tools and techniques for monitoring and detecting the effects of climate change on freshwater ecosystems and the role of the hydrosphere relative to global warming.

Products 1.3

(1) selection and instrumentation jointly with AES of six index stations in region to collect, process and interpret hydroclimatic and water quality data for the purpose of monitoring potential impacts of climatic change on water resources and reporting results annually
Regional **Atlantic (WRB-HQ)** **1991/92 - 1996/97**

Issue 1. **GLOBAL WARMING (Products--Goal 1.3)** (cont'd)

(2) assessment of regional hydrometric network to determine adequacy for detection of effects of long-term climate change on regional water resources; beginning with Ontario pilot project and including contribution of hydrometric data sets to Mackenzie River Basin Impact Study
National **WRB-HQ (Ontario; Western & Northern)** **1991/92 - 1996/97**

(3) analysis of trends in datasets and evaluation of techniques to assess potential impacts of climatic change on regional hydrological characteristics; beginning with Pacific and Yukon pilot project
National **WRB-HQ (Pacific & Yukon)** **1991/92 - 1996/97**

(4) investigation and evaluation of water quantity models for determination of impact of climate change scenarios on water resources and to establish climate change indicators for selected regions of Canada
National **WP&MB-HQ (NHRI)** **1991/92 - ? (timing uncertain)**

(5) evaluation and application of appropriate models for determination of impact of climate change scenarios on water quality and to establish climate change indicators for selected regions of Canada, beginning with the Great Lakes and Atlantic region as pilot projects
National **WQB-HQ (Atlantic, Ontario)** **1991/92 - ? (new res. required)**

(6) evaluation of glacier melt history trends in alpine regions and possible relationship to climatic change
Regional **NHRI** **1991/92 - 1995/96**

(7) assessment of application of remotely sensed optical properties of inland waters to monitoring climate change
National **NWRI** **1991/92 - ? (timing uncertain)**

(8) assessment and editing of historic data sets on Great Lakes relative to climatic variability and change
Regional **NWRI** **1991/92 - ? (timing uncertain)**

Issue 1. **GLOBAL WARMING (Products-Goal 1.3) (cont'd)**

(9) creation of proxy datasets on changes in past climate obtained from paleoenvironmental studies of invertebrates in lake sediments

National	**NWRI**	**1991/92 - ? (timing uncertain)**

(10) development of computer simulation models to evaluate long-term effects of climate warming on physical dynamics (e.g. temperature and circulation patterns) of lakes

National	**NWRI**	**1991/92 - ? (timing uncertain)**

(11) creation of proxy climate datasets through collection and analysis of Mount Logan ice cores to assess historical regional precipitation variability relative to global trends

Regional	**NHRI**	**? (new resources required)**

Goal 1.4 To develop and implement tools and techniques for monitoring and detecting the effects of climate change on water-related human activities and on an integrated, regional basis.

Products 1.4

(1) assessment, adaptation and application of water-use/socio-economic models for study of regional water resource implications of climate change, beginning with the Water Use Analysis Model (WUAM) and the South Saskatchewan River Basin

National	**WP&MB-HQ (NHRI)**	**? (new resources required)**

(2) assessment and improvement of water models for climate change applications through better simulation of basic hydrological processes and feedback mechanisms and through integration of quantity, quality and socio-economic aspects

National	**WP&MB-HQ (NHRI, NWRI)**	**1991/92 - 1996/97**

(3) identification of resource requirements and implementation of studies to predict the effects of climate change/sea-level rise on regional coastal freshwater resources with respect to salt-water intrusion, coastal flooding, coastal erosion, socio-economic impacts and water policy implications

Regional	**Atlantic (WP&MB-HQ)**	**? (new resources required)**

Issue 1. GLOBAL WARMING (**Products--Goal** 1.5) (cont'd)

Goal 1.5 To identify appropriate options for mitigating the most serious negative effects and benefiting from the positive effects of climate change on the freshwater environment and society.

Products 1.5

(1) participation in planning, organizing and implementing AES-led Canada-US international integrated study on responding to potential impacts of climatic change on the Great Lakes
Regional **Ontario (Quebec)** **1991/92 - 1996/97**

(2) advise and influence inclusion of climate change scenarios among long-term options for regional water resource development, beginning with either South Saskatchewan River Basin (Saskatchewan) or the Red-Assiniboine (Manitoba), and James Bay Hydrolelectric Project (Grande Baleine/La Grande)
Regional **Quebec (Western & Northern)** **1991/92 - ? (timing uncertain)**

Issue 2. **ACIDIFICATION**

Goal 2.1 To continue to detect and monitor acidification by SO_2 and NO_2, its effects on aquatic ecosystems, and the impact of limitation and remedial efforts, with increasing emphasis on nitrogen deposition.

Products 2.1

(1) publication jointly with AES of report on sulphur budget for selected watersheds in region
Regional **Atlantic** **1991/92**

(2) establishment collectively with CPS, AES and other partners of integrated water resource monitoring program at Kejimkujik site, incorporating wetland, acidification and climate change dimensions; including collection, analysis, processing and interpretation of water quantity, quality and atmospheric data and report preparation
Regional **Atlantic** **1991/92 - 1992/93**

(3) assessment of role of wetlands in production and storage of organic and inorganic acids and preparation of data report
National **Atlantic** **1991/92 - 1996/97**

(4) monitoring and reporting on process of acidification in Lac Laflamme Watershed experimental site and assessing physical-chemical changes associated with acid precipitation
Regional **Quebec** **1991/92 - 1996/97**

(5) monitoring and detection of trends of lake water quality in response to acidification trends
National **Quebec (Atlantic)** **1991/92 - 1996/97**

(6) completion of Phase II of the acid rain study in Pukaskwa National Park
Regional **Ontario** **1991/92 - ? (timing uncertain)**

(7) integration of GIS, remote sensing and other technologies into tool capable of generating data based on terrestrial indicators of surface water acidification, focusing on nitrogen deposition (Eastern Canada)
National **WP&MB-HQ** **1991/92 - 1996/97**

Issue 2. **ACIDIFICATION (Products-Goal 2.1) (cont'd)**

(8) study for modelling effects of meteorites on NO_x productic
National **WQB-HQ** **1991/92 - ? (timing uncertain)**

(9) statistical evaluation of existing and proposed LRTAP monitoring network and data
National **NWRI** **1991/92 - ? (timing uncertain)**

(10) assessment of biogenic (e.g. dimethyl sulphide from wetlands) contribution to atmospheric sulphur burden
National **NWRI** **1991/92 - ? (timing uncertain)**

(11) assessment of contribution of naturally produced acidity from organic matter (e.g. peat, sphagnum) to acidification of rivers in Nova Scotia
National **NWRI** **1991/92 - ? (timing uncertain)**

(12) testing of hydrogeochemical models under different emission control scenarios and probabilities of snowmelt occurrences
National **NWRI** **1991/92 - ? (timing uncertain)**

(13) assessment of ground water acidification
National **NHRI** **1991/92 - ? (timing uncertain)**

Goal 2.2 To continue to identify and assess the impact of acidification by SO_2 and NO_2 on water-related human activities, with increasing emphasis on nitrogen deposition.

Products 2.2

(1) implementation of three-year action plan for socio-economic component of LRTAP V, based on critical loading approach and focusing on mitigation implications and economic instruments
National **WP&MB-HQ** **1991/92 - 1994/95**

Issue 2. **ACIDIFICATION (Products-Goal 2.3) (cont'd)**

Goal 2.3 To determine loading criteria for limiting acidification impacts in aquatic ecosystems by SO_2 and NO_2 on a regional basis, with increasing emphasis on nitrogen deposition.

Products 2.3

(1) application of snow melt "acid shock" model to assessment of acid, particularly nitrogen, emission and controls and regional loading sensitivities
National **Quebec (Ontario)** **1991/92 - ? (new res. required)**

(2) applications of regional acidification impact modelling using RAISON (Regional Analysis by Intelligent Systems ON microcomputer)
National **NWRI** **1991/92 - ? (timing uncertain)**

(3) evaluation of regional aquatic resources at risk based on relationship between aquatic and terrestrial regime factors
National **NWRI (WP&MB-HQ)** **1991/92 - 1996/97**

Goal 2.4 To provide sound scientific data in readily accessible and usable form for periodic national assessments of aquatic ecosystem and socio-economic responses to emission controls and for national, Canada/U.S. and other multinational negotiations on SO_2 and NO_2 emissions, with increasing emphasis on nitrogen deposition.

Products 2.4

(1) advice, briefings, progress and special annual reports in support of water-related aspects of renegotiation of SO_2 emission controls for post-1994
National **WP&MB-HQ (NWRI)** **1991/92 - 1994/95**

(2) maintainance of LRTAP database as part of NAQUADAT
National **WQB-HQ** **1991/92 - 1996/97**

Issue 3. **AIRBORNE TOXICS**

Goal 3.1 To determine input/output balances and internal cycling behaviour of priority airborne toxics within aquatic ecosystems.

Products 3.1

(1) identification of priority contaminants and potential sites for monitoring in remote locations
National **WQB-HQ** **1991/92**

(2) sampling precipitation for organochlorine contaminants and evaluation for measurement of chlorinated phenols and other toxic substances
Regional **Pacific & Yukon** **1991/92 - ? (timing uncertain)**

(3) preparation of long-term monitoring plans for organic compounds in aquatic ecosystems
National **WQB-HQ (NWRI)** **1991/92 - ? (timing uncertain)**

(4) investigation of major factors controlling exchange of volatile toxic compounds across air-water interface, using recirculating wind-wave flume
National **NWRI** **1991/92 - ? (timing uncertain)**

(5) ongoing monitoring and analysis of long-range transport of contaminants into Arctic snow, ice and aquatic ecosystems; and in support of Annex 15 in the Great Lakes Water Quality Agreement
Regional **NWRI (NHRI, Western & Northern)** **1991/92 - 1996/97**

(6) monitoring and research reconnaisance of atmospheric concentrations and deposition of heavy metals and organic pollutants using plant material (e.g. mosses, peat, pine needles)
National **NWRI** **1991/92 - 1996/97**

(7) assessment of long-term trends in deposition of toxic metals and organic pollutants using sediments from remote headwater lakes
National **NWRI** **1991/92 - 1996/97**

(8) collection and analysis of monthly precipitation samples for organic pollutants at 2 sites in the region
Regional **Atlantic** **1991/92**

Issue 3. **AIRBORNE TOXICS (Products-Goal 3.1)** (cont'd)

(9) accelerated collection and analysis of airborne toxics, cooperatively with AES, to include more sites and a broader range of parameters
Regional **Atlantic** **1991/92 - 1994-95**

(10) identification of effect of temperature on snowmelt runoff processes and release of pollutants from snowpack in high latitude permafrost basins to improve ability to predict effect of climate on northern hydrology, ecosystems and water quality
Regional **NHRI** **1991/92 - ? (timing uncertain)**

Goal 3.2 To identify and monitor effects of priority airborne toxics on aquatic ecosystems and freshwater biota.

Products 3.2

(1) study of effects of trophic status in lakes on the accumulation of atmospherically deposited organochlorine compounds in different levels of the foodweb
National **NWRI** **1991/92 - ? (timing uncertain)**

(2) sampling and analyses of waters, sediments and fish to evaluate airborne toxics concentrations in water ecosystems in the province of Quebec
Regional **Quebec** **1991/92 - ? (timing uncertain)**

Goal 3.3 To determine loading criteria on a regional basis so that aquatic ecosystems are not impaired in their evolution and functioning by airborne toxics.

Products 3.3

IWD is interested, but no specific products are planned or recommended.

Issue 4. **STRATOSPHERIC OZONE DEPLETION**

Goal 4.1 To determine the effects of ambient levels of UV radiation on aquatic ecosystems

Products 4.1

(1) assessment of effects of ambient UV radiations on algal and macrophyte physiology and subsequent effects on primary production and growth
National **NWRI** **1991/92 - ? (timing uncertain)**

Goal 4.2 To conduct experimental research to confirm preliminary evidence of effects of increased UV radiations on aquatic flora and fauna in lakes and rivers.

Products 4.2

(1) assessment of effects of increased UV radiation on aquatic life in lakes
National **NWRI** **1991/92 - ? (timing uncertain)**

Issue: 5. **TROPOSPHERIC OZONE PRODUCTION**

Goal 5.1 To determine the direct and indirect effects on aquatic ecosystems resulting from the absorption of ground-level ozone.

Products NWRI is interested, but no specific products are planned or recommended.

Goal 5.2 To determine the direct and indirect effects on aquatic ecosystems resulting from the attenuation of UV and visible radiations.

Products NWRI is interested, but no specific products are planned or recommended.

LEGEND

Goal = goal statement contained in Strategic Plan (pp 1-4 and 1-5)

National = product or activity rated as an all-region, national priority
Regional = product or activity rated as a region(s)-specific priority

Atlantic (NHRI) = actual and/or potential location of activity: Lead (Partner)

Atlantic, Quebec, Ontario, Western and Northern, Pacific and Yukon = Regions
WP&MB-HQ = Water Planning and Management Branch, Headquarters
WQB-HQ = Water Quality Branch, Headquarters
WRB-HQ = Water Resources Branch, Headquarters
NHRI = National Hydrology Research Institute
NWRI = National Water Research Institute

1991/92 = year 1 of 5-year plan
? = uncertain timing and/or new resources required

Appendix A

BACKGROUND INFORMATION

Inland Waters Directorate
Strategy for Addressing Atmospheric Issues

(May 1991)

INTRODUCTION

Atmospheric Issues

Atmospheric issues are environmental problems that result from changes in the composition and behaviour of the earth's atmosphere. By-products of fossil fuel burning and other human activities are changing fundamental life-support characteristics of the atmosphere and affecting natural resources and sensitive ecosystems. These changes are unprecedented in human history.

Global Warming The buildup of greenhouse gases, such as carbon dioxide and methane, that trap heat in the lower layers of the atmosphere is expected to cause a global warming of the earth's surface at a rate more rapid than any experienced over the past 10,000 years. If greenhouse gas emissions continue unabated, the global mean temperature will increase by about 0.3°C per decade during the next century. Potential negative impacts of global warming include, but are not limited to, reduced water supplies, diminished water quality and altered aquatic ecosystems.

Acidification The combustion of fossil fuels, especially coal and petroleum, results in the emission into the atmosphere of sulphur and nitrogen oxides. These pollutants can be transformed in the atmosphere to form acids that are returned to the earth's surface as acid precipitation, which includes rain, snow and fog. Acid precipitation can be local or long range relative to the source. Acidification of lakes and streams, particularly "spring acid shock" caused by the spring melting of acidic snow, impairs the reproduction and growth of fish and other aquatic organisms.

Airborne Toxics Toxic substances that are injected into the atmosphere include the following: heavy metals from the burning of fossil fuels; PCBs from the burning of treated wood and other refuse; chemical residues from agricultural and forestry activities; and various emissions from industrial processes. Toxic pollutants can travel both short and long distances in the atmosphere before returning to the surface. Previously airborne toxic chemicals can be found in rain, snow, fog, ice, and surface and ground waters. A major concern is the presence of toxic chemicals, which originate from agricultural and industrial areas in the south, in the Canadian Arctic environment and food chain.

Stratospheric Ozone Depletion Chlorofluorocarbons (CFCs) and other chloride compounds that are used, for example, in the manufacturing of refrigerators, react in the upper layers of the atmosphere by destroying ozone. The stratospheric ozone layer ("good ozone"), which protects life on earth from the harmful effects of excessive ultraviolet-B (UV-B) radiation from the sun, is being depleted by these man-made, long-lived chemicals. UV-B radiation causes direct damage to aquatic organisms and could result in significant changes to freshwater ecosystems. CFCs also contribute to the enhanced greenhouse effect and the resultant global warming.

Tropospheric Ozone Production Nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are released during the combustion of fossil fuels and react together in the presence of sunlight to form ground-level ozone, or smog. Tropospheric ozone ("bad ozone") is normally a local, low-level air pollution problem that occurs in and around large urban centres. Ground-level ozone can reduce the yield and vitality of agricultural crops and forest ecosystems and, when absorbed in water, may attenuate UV and visible radiations. Smog can also cause respiratory problems in humans, especially when air quality levels are exceeded. In addition, ozone is a significant greenhouse gas that contributes to the global warming effect.

Collective Rationale

The collective approach to addressing atmospheric issues seeks to integrate the science and policy of several leading environmental problems of today. Current and potential problems, such as acid rain, ozone depletion and climate change, are chemically and physically interrelated, with the main common denominator being the earth's atmosphere. The collective rationale is based also on the recognition that these phenomena and their impacts on natural ecosystems do not respect man-made boundaries. Finally, these issues are commonly related to external costs to present human activities that should be factored into future-oriented decision making. Table 1 summarizes the individual characteristics of and the relationships among atmospheric issues and their associated airborne substances.

Response Strategy

Atmospheric conditions and the hydrological cycle are intimately related. Hydrological changes related to the changing atmosphere affect nearly every aspect of human well-being, from adequate water supplies to flood control. Atmospheric issues, whether viewed singularly or collectively, are extremely complex. Dealing with these problems requires significant resources and both interdisciplinary and intergovernmental collaboration. The fact that science has revealed common sources, processes and pathways for the atmospheric issues in question verifies the need for policymakers and program managers, including those within the

Table 1

PREDOMINANT AIRBORNE SUBSTANCES AND RELATED ATMOSPHERIC ISSUES

	SUBSTANCE	ANTHROPOGENIC SOURCES	ATMOSPHERIC ISSUE
CO_2	Carbon dioxide	fossil fuels, deforestation	global warming
CFCs	Chlorofluorocarbons	refrigerants, aerosols	global warming, stratospheric ozone
CH_4	Methane	cattle, wetlands, biomass burning	global warming
HCB	Hexachlorobenzine	pesticides	airborne toxics
HCHs	Hexachlorocyclohexanes	pesticides	airborne toxics
N_2O	Nitrous oxide	fertilizer, fossil fuels	global warming
NO_x	Nitrogen oxides	fossil fuels	tropospheric ozone (with VOCs and sunlight), global warming (N_2O), acidification (NO_3)
NO_2	Nitrogen dioxide	fossil fuels	acidification
O_3	Ozone	NO_x, VOCs (with sunlight)	global warming, stratospheric ozone, tropospheric ozone
PCBs	Polychlorinated biphenyls	plasticizers, flame retardents	airborne toxics
SO_2	Sulphur dioxide	fossil fuels	acidification
VOCs	Volatile organic compounds	industry, solvents	tropospheric ozone (with NO_x and sunlight), global warming (CH_4, CFCs), airborne toxics (benzine, etc.), stratospheric ozone (CFCs)

Inland Waters Directorate, to address these major challenges based on a collective approach and a collaborative effort. The development and implementation of an **IWD Strategy for Addressing Atmospheric Issues** is intended to move beyond an ad hoc level of knowledge to an accurate understanding and common awareness of the relevant environmental problems. The Strategy will provide guidance and coordination for a cohesive and proactive response to these issues in place of the currently fragmented and duplicative reaction, if not inaction. The Strategy will inform others about IWD priorities and activities relative to atmospheric issues, which is important for developing partnerships. Finally, the Strategy is expected to improve the efficiency and effectiveness of the overall IWD response to atmospheric issues.

CONSIDERATIONS

IWD has a vital role to play, both nationally and internationally, in responding to atmospheric issues. In order to articulate this role and to define specific goals and responsibilities, it is necessary to identify the pertinent circumstances and their implications relative to the mandate and capabilities of IWD.

International Context

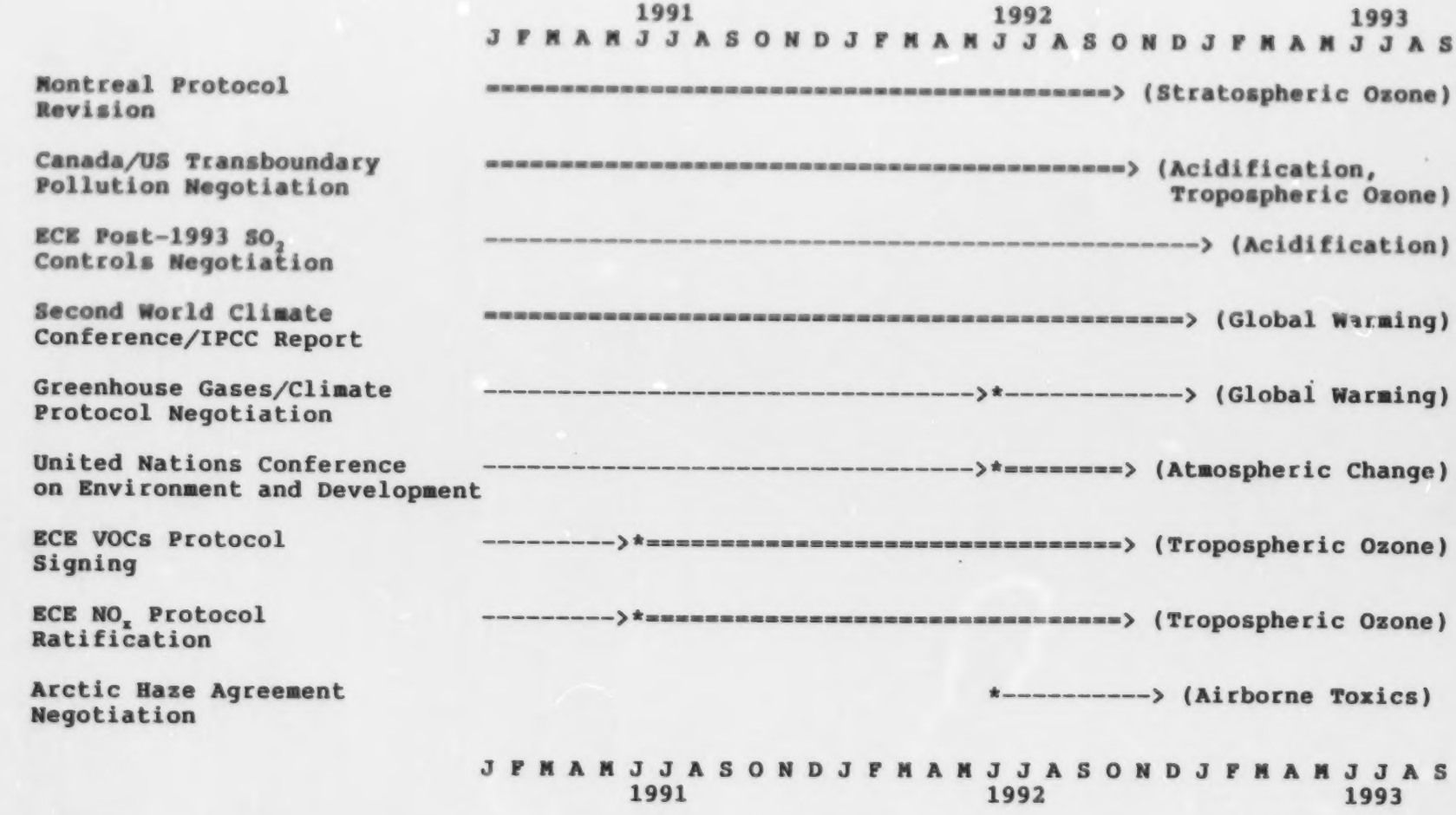
Atmospheric issues and their impacts are recognized around the world by both political and scientific leaders as a serious threat to human health and the global environment. Figure 1 summarizes the timelines of selected multi-national and bilateral initiatives related directly to atmospheric issues that are in different stages of negotiation and implementation. While these are efforts designed to limit or eliminate sources of the problems (i.e. emission reductions), IWD has been or is expected to be among those consulted regarding the associated environmental impacts. It is normally the identification and assessment of the latter that act as the catalyst for action on the former. Also, these international actions often have provisions for research and information exchange on environmental impacts.

Individuals and organizations within IWD are involved in the planning and implementation of several permanent and special international activities that are addressing various aspects of atmospheric issues. IWD experts contributed and coordinated input to the state-of-the-art report prepared by the Intergovernmental Panel on Climate Change, created in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). IWD representatives are participating in the implementation of the Canadian Global Change Program, Canada's contribution to the International Geosphere-Biosphere Program,

Figure 1

TRACKING ATMOSPHERIC ISSUES

INTERNATIONAL


1991
1992
1993
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
Montreal Protocol Revision
(Stratospheric Ozone)
Canada/US Transboundary Pollution Negotiation
(Acidification, Tropospheric Ozone)
ECE Post-1993 SO2 Controls Negotiation
(Acidification)
Second World Climate Conference/IPCC Report
(Global Warming)
Greenhouse Gases/Climate Protocol Negotiation
(Global Warming)
United Nations Conference on Environment and Development
(Atmospheric Change)
ECE VOCs Protocol Signing
(Tropospheric Ozone)
ECE NOx Protocol Ratification
(Tropospheric Ozone)
Arctic Haze Agreement Negotiation
(Airborne Toxics)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1991
1992
1993

LEGEND: * = milestone; ---> = preparation; ===> = implementation; (Acidification) = issue relationship; [dates are approximate].

which operates under the umbrella of the International Council of Scientific Unions (ICSU).

IWD's National Hydrology Research Institute is co-leader of the Canadian contribution to the Global Energy and Water Cycle Experiment (GEWEX), a major initiative jointly directed by ICSU and WMO. While the GEWEX involvement at NHRI is more on water and energy fluxes at the earth's surface rather than specifically on the atmospheric component, the former obviously responds to the latter. IWD's National Water Research Institute is the data banking centre for the Global Environmental Monitoring System/Water (GEMS/Water), a UNEP and World Health Organization collaboration. The traditional water quality monitoring activities of GEMS/Water, which include toxic chemical loadings, were expanded in 1989 to include a major effort in data interpretation and assessment in relation to sustainable water resource development.

IWD experts are active participants in the Finnish Initiative, being led by the eight circumpolar nations, on environmental monitoring and protection in the Arctic; the International Hydrological Program (IHP) of the United Nations Educational, Scientific and Cultural Organization (Unesco); and the joint Canada-United States Northern Wetlands Project, Great Lakes-Climate Change Regional Response Study and Boreal Ecosystem-Atmosphere Study (BOREAS). IWD is also committing a significant effort in the area of airborne toxics under Annex 15 of the Canada-United States Great Lakes Water Quality Agreement (GLWQA). The common theme of these initiatives relative to atmospheric issues is the impact of human activities and a changing environment, through air-land-water interaction, on hydrological and socio-economic systems.

National Context

IWD is intimately involved in the major national initiatives designed to address atmospheric issues. Figure 2 illustrates the timing for planning and implementation of these actions and their respective relationship to atmospheric issues. As noted above under international activities, Canadian domestic actions are concerned primarily with reducing emissions into the atmosphere of substances linked to human health and environmental problems. Nevertheless, IWD has contributed significantly to the basic understanding of the freshwater perspective on these issues and to the development of these response initiatives.

The federal Green Plan, the National Action Strategy on Global Warming, and the national Management Plan for NO_x and VOCs, the latter two prepared by the Canadian Council of Ministers of the Environment (CCME), vary in their emphasis on environmental impacts and adaptation options for atmospheric issues. The implications for IWD of implementing these key initiatives are discussed elsewhere in this document. Meanwhile, IWD representatives are active on various advisory committees and working groups for the

Figure 2

TRACKING ATMOSPHERIC ISSUES

NATIONAL

1991
1992
1993
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
CCME National Action Strategy on Global Warming
-----> * ==========> (Global Warming)
Federal Green Plan
-----> * ==========> (Atmospheric Change)
CCME Management Plan on NO_x/VOCs
-----> * ==========> (Tropospheric Ozone)
Federal/Provincial Post-1994 SO_2 Controls Negotiation
* ----------> (Acidification)
National Assessment of CO_2 Reductions
* ----------> (Global Warming)
Great Lakes Action Plan (Annex 15, Great Lakes Water Quality Agreement)
==========> (Airborne Toxics)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1991
1992
1993

LEGEND: * = milestone; ---> = preparation; ===> = implementation; (Acidification) = issue relationship; [dates are approximate].

Canadian Climate Program, lead by the Atmospheric Environment Service (AES), and the national program on Long Range Transport of Airborne Pollutants (LRTAP), coordinated through a CCME committee structure that is presently under review.

IWD ACTIVITIES

IWD is already spending significant resources on various atmospheric issues. However, IWD has not yet established an overall policy, strategy, action plan or program element for atmospheric issues. As demonstrated above, IWD must be better prepared to respond to commitments contained in federal, national and international initiatives.

Current Efforts

Preliminary surveys of 1990-91 A-base resources indicate that IWD is spending approximately $1 M (O&M and capital) and 53 PYs in addressing atmospheric issues, which represent about 1 and 5 percent, respectively, of total IWD non-salary dollars and person-years. The approximate breakdown of expenditures is as follows:

	$K	PYs
Global warming	570	9
Acidification	315	35
Airborne toxics	115	9

No significant resources were linked to IWD work on tropospheric or stratospheric ozone. About $500 K and $350 K in non-A-base funds under, respectively, the LRTAP IV Program and Annex 15 of the Great Lakes Water Quality Agreement, were spent by IWD on acidification and airborne toxics, with non-A-base funds for other sub-issues being relatively nominal.

The largest portion of IWD expenditures occur at the research institutes for biophysical impact assessment related to global warming and airborne toxics. Spending levels are about equal between the regions and the institutes for acidification. Very minimal resources are spent at headquarters on all issues and for socio-economic impact assessment at all locations.

Partners in collaborative and joint activities include the following: other sectors of C&P (e.g. Canadian Wildlife Service); other services within DOE (e.g. Atmospheric Environment Service); other government departments (e.g. Fisheries and Oceans); special groups (i.e. Canadian Institute for Research on Atmospheric Chemistry); and other national agencies (e.g. NASA of the United States).

An overall lead role for atmospheric issues does not exist within IWD; however, key individuals are as follows:

D.A. Davis (DG, IWD)--IWD member of C&P Atmospheric Issues Steering Committee and C&P Responsible Manager for LRTAP and climate change;
E.L. Kulin (PACB, HQ)--IWD member (acting) of C&P Atmospheric Issues Coordinating Committee;
D.S. Jeffries (LRTAP Project, NWRI)--IWD LRTAP Coordinator and leader of the C&P LRTAP Research and Monitoring Project;
W.B.G. Smith (WPMB, HQ)--LRTAP Socio-Economic Coordinator, leader of the C&P LRTAP Socio-Economic Project, and lead on C&P LRTAP program review (in progress); and
T.J. Marta (PACB, HQ)--Coordinator of the IWD Network on Atmospheric Issues.

Figure 3 shows how IWD is positioned within the national structure, including the DOE "issues management" system, that is evolving to deal with cross-sectoral environmental concerns such as atmospheric issues. Given its broad mandate and national perspective, the Canadian Council of Ministers of the Environment (CCME) is addressing with varying intensity all of the atmospheric issues that are of concern to IWD. To date, issue management committees at Levels A and B have been established within DOE for acidification, global warming and NO_x/VOCs.

The C&P Level C committees, with representation from CWS, EP, IWD headquarters and Ontario and Western and Northern regions, were approved in January 1990 by C&P Management Board and have been meeting since April. The C&P Atmospheric Issues Coordinator acts as a secretariat to the C&P committees. An **IWD Network on Atmospheric Issues**, consisting of regional, institute and HQ representatives, was formed in July 1990 following its approval at the May 31 meeting of IWD Directors. The Network is used as required in support of IWD input to the C&P Level C committees. Some members from the C&P Level C committees, including IWD representatives, also sit on the two interdepartmental committees (the Intedepartmental LRTAP Committee is presently under review).

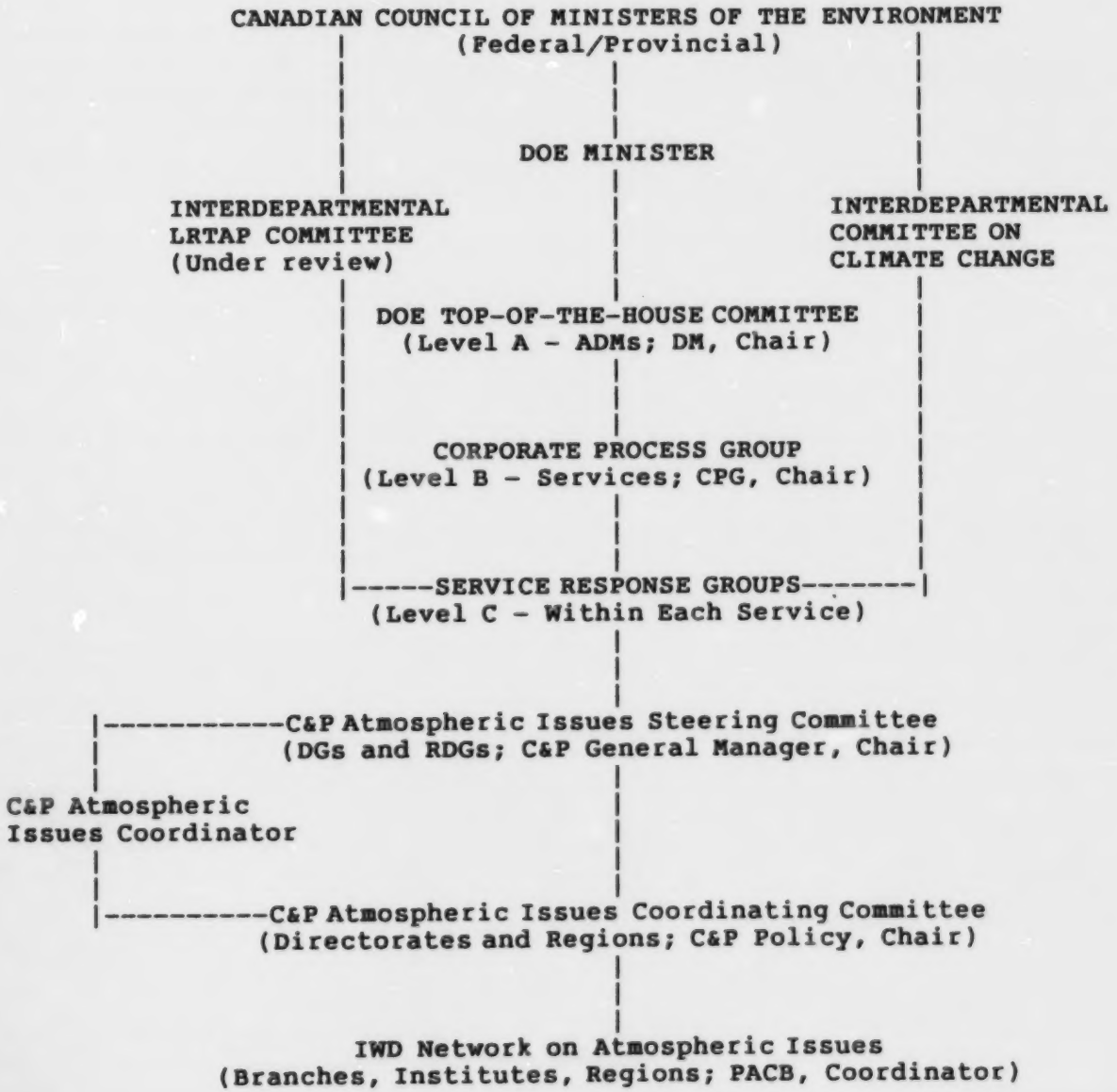
Near-Future Commitments

Basic commitments to atmospheric issues as they pertain to water are contained in the **Federal Water Policy** (1987) through Specific Policy Statements on Climate Change, Management of Toxic Chemicals, and Research Leadership. Under climate change, for example, the FWP states that the federal government will

- make effective use of climatological information in water resources planning and management;
-conduct further research on the relationship between climate and water resources; and
- conduct further research on the impact of climate change and variability on water resources.

Figure 3

NATIONAL MANAGEMENT STRUCTURE FOR ATMOSPHERIC ISSUES



The management of toxic chemicals throughout their life-cycle requires adequate understanding and monitoring of their sources, transport and sinks. Providing leadership in water research is to be directed to current and emerging issues of federal, national and regional significance.

The **IWD Strategic Plan** (1990), among other functions, positions IWD to deliver programs in support of the FWP. The Plan states the water mission of IWD as follows:

> - to promote wise management and protection of water in Canada and globally as a vital contribution to sustainable development.

The Plan focuses on the challenge of problems, such as acid rain, toxic substances and climate change, resulting from our changing environment. The strategies established by the Plan, particularly those on water research, toxic substances and environmental forecasting, provide guidance on how to address these and other major issues.

The national **Management Plan for Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOCs)** received approval in principle from the CCME in November 1990. The focus of the Plan is on the reduction of ground-level ozone, for which NO_x and VOCs are the precursor pollutants. The NO_x/VOCs-related environmental problems are expected to be resolved by the Plan, but are only secondary considerations relative to emission controls. The Plan will be implemented jointly by federal, provincial and municipal jurisdictions.

The **National Action Strategy on Global Warming** is being called a "high-level generality" which was being prepared for presentation at the Second World Climate Conference in Geneva at the start of November 1990 and for consideration by the CCME, also in November 1990. The main components of the Strategy, which is a collaborative federal/provincial initiative, are as follows:

> - limitation of greenhouse gases;
> - anticipation of and preparation for potential environmental and socio-economic repercussions of climate change; and
> - improved scientific understanding and prediction.

The guiding principles for the Strategy are:

> - comprehensive approach to reduction of emissions of all major greenhouse gases;
> - consideration of the international context; and
> - flexibility and adaptability of response strategies.

Measures and processes for the reduction of emissions of greenhouse gases are the predominate aspects of the Strategy. The Strategy

will be considered for approval by the CCME following a review by federal and provincial energy ministers. Most of the program details for the federal portion of the Strategy are included in the Green Plan.

The Green Plan, or Environmental Agenda, which was released in December 1990, describes the most serious national and global environmental problems and provides a plan of action for the federal government. Implementation of the Green Plan will begin in April 1991. Atmospheric Change, which is among the target areas for action, includes the following phenomena: global warming, acid rain (acidification), toxic air pollutants (airborne toxics), local air pollution (tropospheric ozone), and (stratospheric) ozone depletion. It is notable that, under the Green Plan, the centralized B-base funding of the federal LRTAP Program (i.e. acidification) is being dispersed into A-base budgets, and departments are expected to adjust accordingly. As a result, the C&P LRTAP program, through which IWD activities are presently managed, will be reviewed and modified as required.

The basic approach for implementing the Green Plan goal of environmental decision-making for sustainable development involves the following:

- improve the factors that affect decision-making, such as better science and more information about the environment;
- change decision-making processes and institutions by formally recognizing environmental considerations as essential criteria; and
- strengthen and build partnerships internationally and nationally with the provinces, communities, industry, special interest groups and individuals.

The Green Plan is expected to be the main guiding policy and action plan, as well as a source of new resources, over the next several years for federal responses to atmospheric issues and other environmental problems.

Longer-Term Needs

The near-future commitments of IWD, as influenced by the key policy, strategic and action instruments noted above, determine to a large extent the longer-term needs for IWD responses to atmospheric issues. The following are six priority areas where future IWD work is expected to be concentrated relative to atmospheric issues. Themes that are common to some or all of the priority future actions include the following: environmental monitoring, information communication, interdisciplinary teamwork, regional assessment, and stakeholder partnerships.

Improved understanding of the hydrological cycle is a basic science requirement for describing the response of the cycle components and

processes to the input and impacts of atmospheric contaminants, in addition to other natural and anthropogenic changes. Communication and explanation of new knowledge to policymakers, program managers, the general public and other users is an important follow-up function. IWD research capabilities in this area are strong but require enhanced resourcing to meet the increasing demand, domestically and internationally, for improved understanding of the physical processes of the hydrological cycle, especially from the biological/ecological perspective.

Improved understanding of the cumulative effect of atmospheric and other environmental issues on aquatic ecosystems is a relatively new area of scientific inquiry. In reality, each ecosystem is being affected by a variety of both natural and anthropogenic stresses, including various atmospheric inputs, that result in interactive responses within and between ecosystems. Development and communication of new knowledge on cumulative ecosystem effects will contribute, for example, to more scientifically accurate environmental impact assessments. IWD work in this area should also be linked to the implementation of integrated environmental monitoring. The IWD research capability to address this complex science issue exists; however, current efforts are at the conceptual stage and require new commitments to program definition, research coordination, and external partnerships.

Improved hydrometric monitoring is a fundamental programming need that should be based on a complete inventory and network evaluation of water quantity, quality and sediment stations, particularly in the North. The required effort involves mainly the improvement of the station network density, of its ecosystem representation, and of water quality/quantity integration. Reconciliation of this need is linked to implementation of integrated environmental monitoring. Also relevant is the aspect of new and improved instrumentation and methodologies, including remote sensing applications, for the detection and measurement of substance levels and related impacts in aquatic ecosystems. This work has technology development and transfer implications.

IWD should continue improvement of its efforts to provide readily accessable data for science, impacts and response applications. An important consideration in this area is the IWD contribution to the national State-of-the-Environment (SOE) reporting and the international Global Environmental Monitoring System (GEMS/Water, expanded form) and Global Energy and Water Cycle Experiment (GEWEX) activities. Much enhanced capital investment and operating resources are needed for adequate IWD action in this area.

Refined identification and assessment of impacts, which are based on sound disciplinary research by natural and social scientists working as interdisciplinary teams, are needed for relevant atmospheric issues. Special efforts are required relative to **increased UV-B radiation, ground water, water quality and**

socio-economic impacts. For example, IWD needs to improve its capability to identify and confirm trends in regional and national water resources resulting from climate change. Promising opportunities exist through the application of existing IWD modelling systems (i.e. RAISON and WUAM) and the linking of artificial intelligence and modelling for improved impact forecasting and scenarios.

Assessment of the vulnerability and resilience of water ecosystems and their dependent socio-economic systems to the impacts of atmospheric issues is needed to identify the most sensitive cases. Multidisciplinary impact studies are required in priority regions such as the North, the Fraser River estuary, the western cordillera, the Prairies, the Great Lakes, James Bay and the Atlantic coast. This type of activity will contribute to the need to incorporate atmospheric issues into applications of the Environmental Assessment Review Process. Current work within IWD on these topics is preliminary and is in need of stronger promotion and resource commitments.

Enhanced identification and assessment of response options relative to the hydrological and water resource implications of atmospheric issues is emerging as the newest challenge requiring attention within IWD. Preliminary work is needed on assessing existing and proposed water policies and programs as they pertain to the limitation of and adaptation to impacts related to atmospheric issues. Water planning and management practices and, particularly, engineering design critieria for water supply development require review and perhaps amendment. An initial focus is needed on the water systems and related socio-economic systems assessed as the most sensitive or at risk to a net negative impact of one or more of the atmospheric issues. New and innovative approaches in this area (e.g. economic instruments, risk analysis and hindcasting), involving less traditional water specialists in economics and political science as well as generalists in both the natural and social sciences, require encouragement and increased commitments within IWD.

Support for negotiations, positions, communication and awareness is required for national, federal and water sector interests. Mechanisms being developed for the various domestic (e.g. National Action Strategy on Global Warming) and international (e.g. Great Lakes Water Quality Agreement, Finnish Initiative) actions relative to atmospheric issues need input from IWD experts. IWD needs to communicate convincingly with stakeholders such as other government departments, the provinces, industry, the general public and international organizations. IWD has good experience in this area, but requires refinement of its own positions and strategies on atmospheric issues to facilitate meeting the challenge of its overall mandate and responsibilities.